As of January 14, 2013 the Heschong Mahone Group, Inc. joined TRC Companies, Inc.

TRC is a respected peer in the energy efficiency consulting industry. Together, we strengthened our position at the forefront of this market and bring our clients access to expanded service capabilities and a national footprint. Please enjoy this paper as a representation of what the Heschong Mahone Group brought to the table, as well as what the newly joined TRC team can bring for the future.

NRG SYSTEMS, HINESBURG, VT

Project Highlights

- "Daylight" windows separated from "view" windows
- Advanced daylight-redirecting blinds
- Low partitions, with desks oriented at right angles to windows
- "Open loop" photocontrol system

NRG Systems is a manufacturer of wind-measurement systems for the wind turbine industry. NRG's towers, wind sensors and data loggers help their clients to effectively site and operate wind turbines.

Part of their commitment to "improving our world and protecting the environment" is a 31,000 sf manufacturing and office building that includes a wide range of sustainable features.

This case study focuses on the south-facing office areas, and how incoming sunlight and diffuse daylight is managed by advanced window blinds, to create a comfortable and efficient workplace.

NRG's building is located in Hinesburg Vermont, between Lake Champlain and the first ridge of the Green Mountains. The elevation is 300', latitude 44°N, and the climate is temperate with cold winters and moderate summers. Frequent winter snow and low winter sun angles create bright and challenging visual conditions for the south-facing spaces.

DAYLIGHTING DESIGN

The south-facing offices have a continuous row of 2’ high daylighting windows between 8’ and 10’ from the floor, supplemented by view windows below. The view window sills are at 3’6”, with a 7’ head height. The view windows occupy about 45% of the width of the façade and are broken up according to the functional areas within. Overall the window to wall ratio[1] is approximately 50% and visible light transmittance of the glass is 41%.

South facing office with advanced blinds and roller shades. Note pattern of re-directed sunlight on the ceiling, and the orientation of suspended luminaires parallel to the window wall.

All the upper windows, and some of the view windows, are fitted with innovative inverted, mirror-finish blinds manufactured by Warema. These blinds are set at an angle to redirect incoming sunlight up to the ceiling. In the lower view windows, the blinds also have perforations along the inner edge to preserve a filtered view out of the window even if the blinds are fully closed to block sunlight.

The view windows in some open office areas are fitted with woven roller shades manufactured by Mechoshade. The shades are designed to shield occupants near the windows from solar heat, and to reduce glare from low-altitude sun.

Both sets of blinds are manually controlled by occupants, rather than by automatic systems. Interior daylight levels are increased by high reflectance walls (75%) and ceiling (90%), and by low (4’6”) partitions between desks.

[1] Measured relative to the exterior wall area

LIGHTING CONTROLS

Advanced reflective blinds bounce sunlight up to the ceiling.

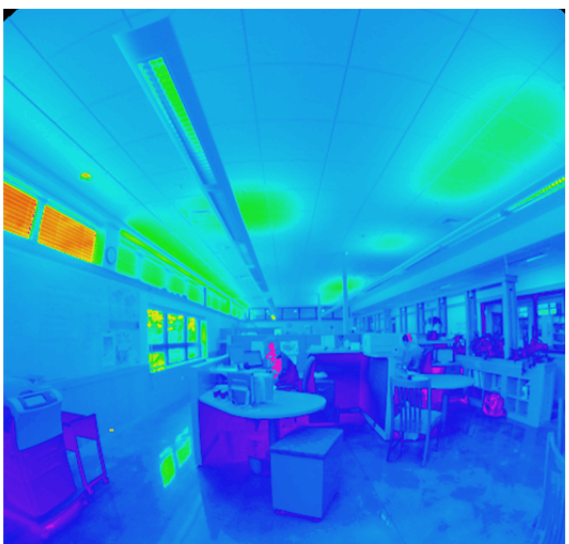
The electric lighting system provides direct/indirect light from suspended luminaires, arranged in two rows parallel to the windows.

The control system is a centralized "open loop" system, which dims luminaires to different levels in response to a daylight reading from a single sensor positioned in a south-facing second-floor clerestory. The location of the sensor was chosen to replicate the orientation and view available from the office windows.

The building's energy management system constantly tracks lighting energy use, and can give hourly energy use for each lighting circuit.

The open office ambient lighting system provides around 28 footcandles and has an installed power density of 1.3 W/sf. It is also controlled by auto-on/auto-off occupancy sensors.

VISUAL ENVIRONMENT



Luminance map showing reduced window contrast due to light bounced upward by the advanced blinds. Green areas indicate brighter areas from reflected sunlight and/or luminaires.

The visual environment is a truly open office without partitions, which allows daylight to spread across the entire space, and allows occupants to have long views both within the space and through windows to the outside.

Light colored surfaces reduce contrasts to increase visual comfort. Contrast between the windows and the ceiling is reduced due to light bounced up by the advanced blinds.

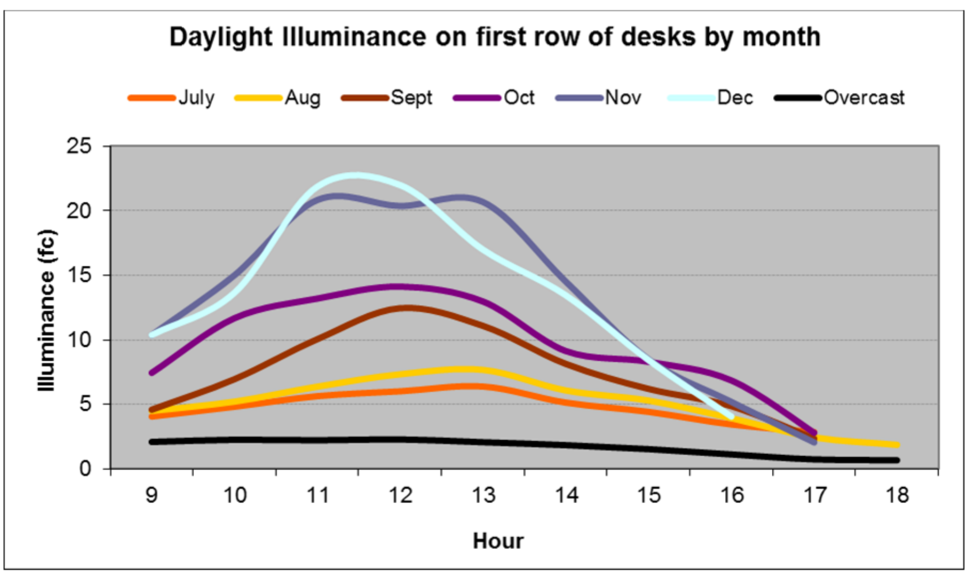
DAYLIGHTING PERFORMANCE

The graph below shows weekday illuminances from daylight, on the first row of desks next to the window. Illuminances were measured by a ceiling-mounted sensor looking down at the desk area. The colored lines show sunny days, broken out by month, while the black line shows overcast days.

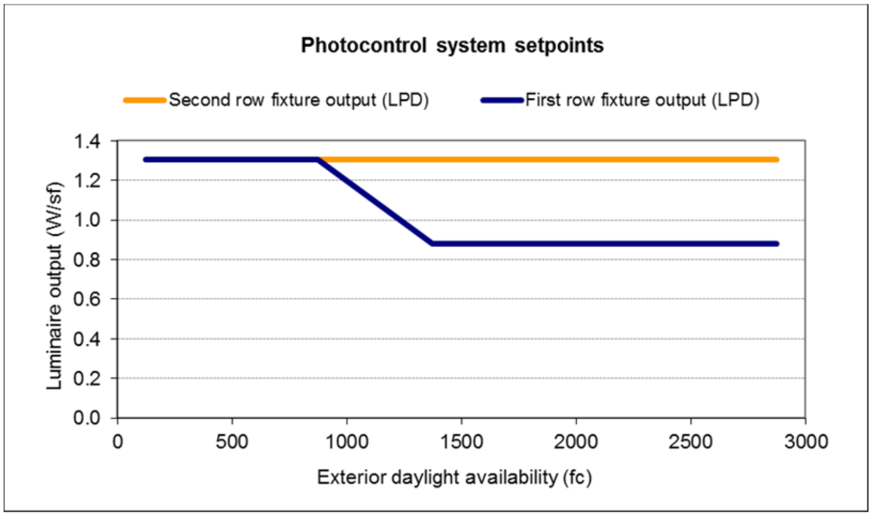
Daylight illuminance is higher in the winter months than the summer months, which suggests that the window blinds (and winter snow) are successfully redirecting low-angle sunlight on to the ceiling while allowing occupants to control solar glare. In the summer the first floor upper windows are shaded by a photovoltaic array mounted above them, also reducing sun penetration. In this building, sunny days produce brighter interior conditions than overcast days.

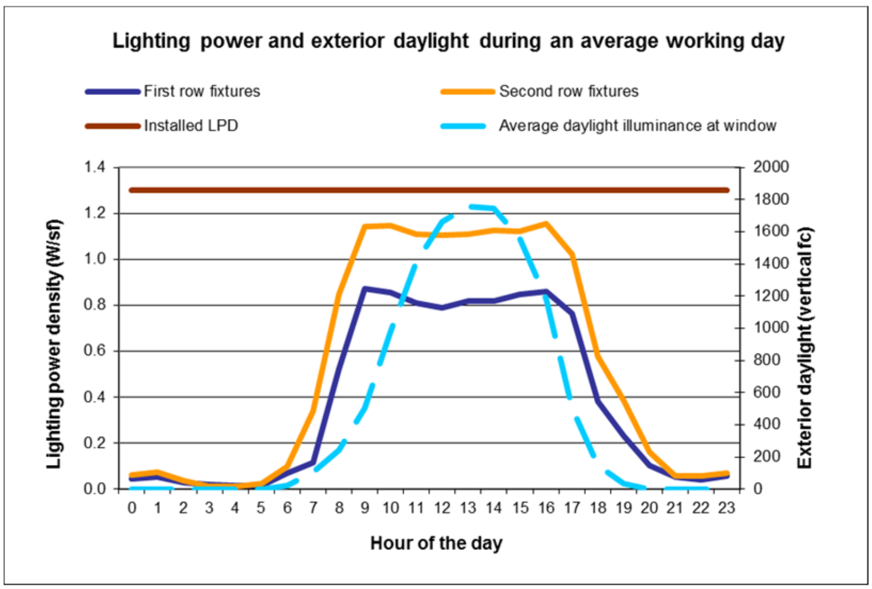
The "daylight autonomy" for the first row of desks is 27% (i.e., daylight levels exceed the working illuminance of 30 footcandles for 27% of the time between 8:30 and 5:30, over the course of a year). Daylight autonomy for the second row of desks is 8%. These values are low compared with good design-phase daylight autonomy values (typically >70% for the first row, and 40-60% for the second row), but the values at NRG are *measured* values of daylight autonomy, i.e., they include reductions in daylight levels due to the occupants' use of blinds.

The graph below shows that although daylight levels were consistent, they were low, most likely due to the blinds being partially closed by occupants.



ENERGY PERFORMANCE





Energy performance was logged between July and December, to include a complete range of solar angles.

The two rows of open office luminaires respond to daylight differently, as shown by the measured data in the graph below. The set-points for the second row mean that it does not begin to dim down until the exterior illuminance reaches 3,000fc (a sunny, or bright overcast day). The first row begins to dim down at 900fc, and reaches its lowest level (around 60% output) when the exterior daylight level is 1,500fc (an average overcast day).

The open office lighting system typically consumes 0.9 W/sf during the work day, compared to its installed power of 1.3 W/sf—a reduction of 31%. This reduction is due to occupancy control of some luminaires, as well as to the photocontrols.

Based on the whole six month period of data collection, the lighting is estimated to consume 2.7 kWh/sf annually. A building with the same installed lighting power density, with the lighting switched on for the typical 3000 hours per year would consume 4.2 kWh/sf annually, so the NRG building saves 36% relative to that base case. A newly-constructed and non-daylit building would require less installed lighting power to meet code, and would typically consume approximately the same amount of lighting energy as the NRG building with its advanced daylighting features.

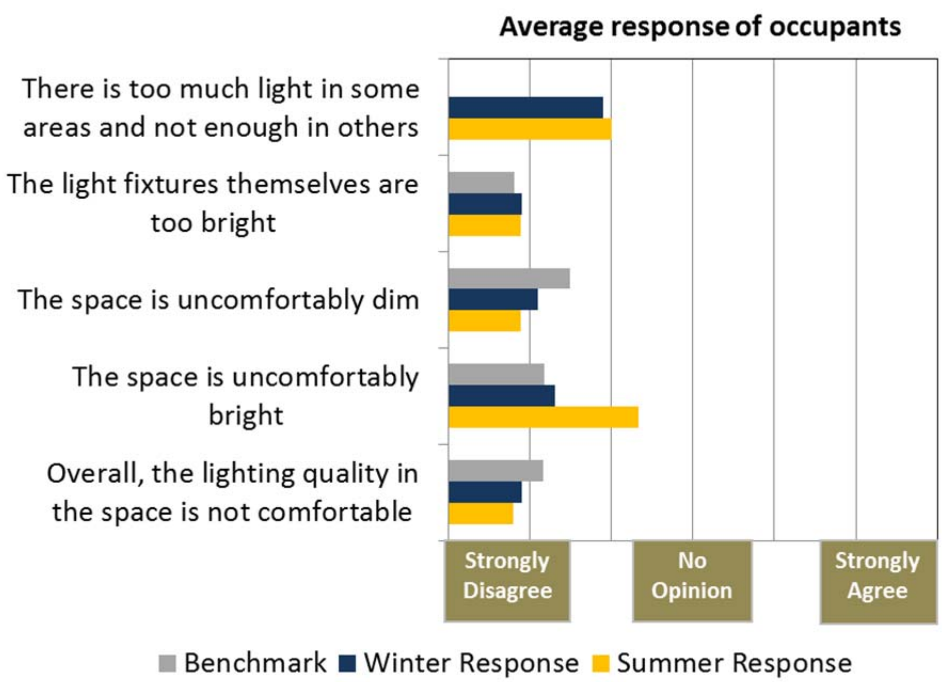
OCCUPANT COMFORT SURVEYS

An online survey of the occupants received 16 complete responses. Two surveys were conducted—one in the summer and one in the winter to see whether the performance of the system differed over the course of the year. For four of the questions, the results are shown relative to a benchmark of high performance daylit buildings from a recent study[2].

The overall response to lighting quality was strongly positive (positive responses are to the right on the chart below). However, one third of the survey respondents found the space to be uncomfortably bright, and this was due to daylight rather than electrical lighting. The occupant responses remained consistent between summer and winter except for complaints about excessive brightness being slightly higher in summer, although this was not a statistically significant difference due to the small number of responses.

In lighting research, complaints of excessive brightness are almost never due to high overall levels of light; instead they are due to glare from specific sources such as direct or reflected sunlight coming through gaps in the roller shades. The responses to every question were statistically significant, i.e. they were different from "no opinion".

A third of the respondents felt the space was uncomfortably bright due to daylight rather than electrical lighting.



[2] Heschong Mahone Group. 2011. *Daylight Metrics Project: Final Report*. California Energy Commission, PIER program.

LESSONS LEARNED

- The dimming photocontrol system at NRG is successful. We estimate that it saves 20-30% of lighting energy use compared with having the luminaires at full output, while achieving light levels consistent with IES guidance, and maintaining high levels of occupant comfort.
- Because the first row fixtures dim down to only 60% output, and the second row fixtures do not dim down at all, the savings could technically have been much greater.
- The advanced blinds are effective at bouncing sunlight up to the ceiling, increasing daylight penetration into the interior spaces and improving the brightness and uniformity of the daylighting
- Some occupants report that the space is “uncomfortably bright” in the summer. This may be due to sunlight penetrating through the roller blinds, especially at lower sun angles in the morning and evening. Adjustable blinds may have been a better choice, which occupants could have positioned to block varying sun angles as needed. Adjustable blinds with perforations can preserve a filtered view while also blocking the sun.
- Measured daylight autonomy levels are comparatively low. Using adjustable blinds instead of roller blinds may have helped to increase daylight autonomy and increase savings from the photocontrols.
- Additional savings may have been achieved by using manual-on rather than automatic-on occupancy sensors, requiring occupants to choose to switch the lights on when they enter the space, if adequate daylight is not present.
- A later addition of photovoltaic cells mounted above the south-facing daylight windows on the lower floor creates some shading of these windows during the summer, reducing the daylight energy savings.